Calc-alkaline magmatic trends at crustal pressure and high f_{O2}

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In the western Aleutian Islands, on thin oceanic crust, strongly calc-alkaline (Fe-depleted) compositions, reminiscent of continental crust, are erupting. Hydrous and/or oxidizing conditions during crystallization drive Fe-depletion along liquid lines of descent [1]. However, experiments have yet to reproduce the very strong Fe-depletion trends observed in the western Aleutians, and mixing may also generate major element trends that only mimic liquid lines of descent [2]. To further constrain the origin of these compositions, we analyzed tephras from Buldir Volcano obtained during the 2015 field season of the GeoPRISMS shared platform. Tephras contain ol+ plg + cpx + sp ± hbl [3]. FTIR measurements of olivine-hosted melt inclusions from Buldir indicate a very hydrous magma (up to 6.8 wt.% H_2O). We conducted a series of H_2O-saturated phase equilibrium experiments (1175-1000°C; 100 MPa) in a rapid-quench cold-seal apparatus on the most primitive natural lava from Buldir (9.3 wt% MgO) at oxidizing conditions near the Re-ReO_2 buffer. Liquid compositions follow the observed Fe-depletion trends and are attributable to early saturation of Cr-spinel and later titanomagnetite. In contrast to the natural samples, the experiments show enrichment in TiO_2 with decreasing MgO, despite crystallization of titanomagnetite, suggesting that higher pressures may be required to stabilize hornblende closer to the liquidus. As MgO falls below ~4 wt.%, P_2O_5 concentrations in the experiments increase while natural concentrations remain low and become scattered, consistent with mixing of a more evolved liquid at lower MgO. We conclude that crystallization under hydrous, oxidizing conditions can drive mafic liquids toward Fe depletion and calc-alkaline compositions; however, it cannot account for Buldir's more evolved compositions. More broadly, our experiments show that oxygen fugacity, not pressure, exerts the dominant control that drives Fe-depletion and calc-alkaline differentiation; thick crust is not required [3].

[1] Osborn (1959) AJS [2] Yogodzinski et al. (2015) JPET and (2017) EPSL [3] Waters et al. (in revision at JPET)